Exercise 2: Connecting the Digital Logic Circuits

EXERCISE OBJECTIVE

When you have completed this exercise, you will be able to connect digital logic circuits and observe the inputs and outputs by using the DIGITAL LOGIC FUNDAMENTALS circuit board. You will verify your results with a multimeter and an oscilloscope.

EXERCISE DISCUSSION

Two basic logic gates are demonstrated by each of the following circuit blocks:

AND/NAND circuit block

OR/NOR circuit block

XOR/XNOR circuit block

OPEN COLLECTOR circuit block

TTL/CMOS COMPARISON circuit block.

One logic circuit is demonstrated by each of the following circuit blocks:

SET/RESET FLIP-FLOP circuit block

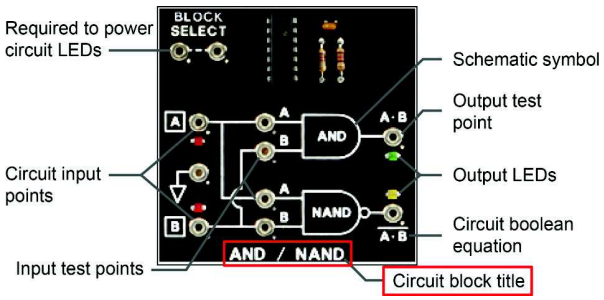
D-TYPE FLIP-FLOP circuit block

JK FLIP-FLOP circuit block

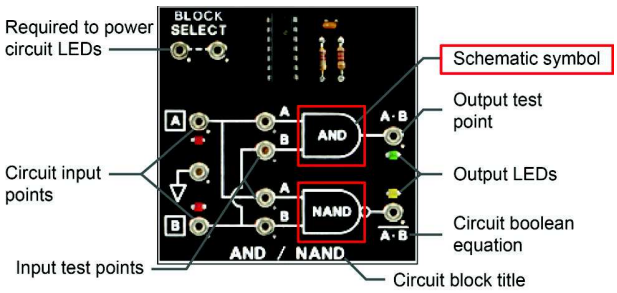
TRI-STATE OUTPUT circuit block.

The DATA BUS CONTROL circuit block combines three logic functions to demonstrate data transfer.

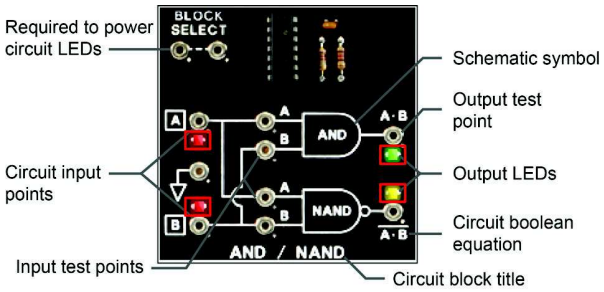
Every circuit block has a title. This is the AND/NAND circuit block.



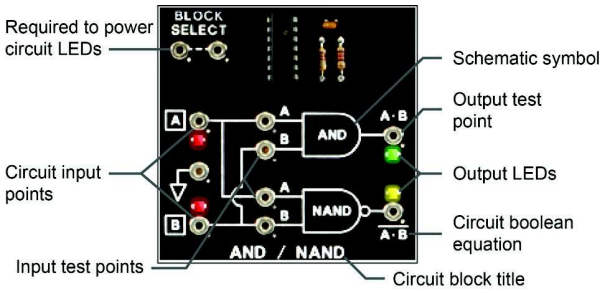
The schematic symbols for the logic gates are silkscreened on the circuit board, as shown on the AND/NAND circuit block.



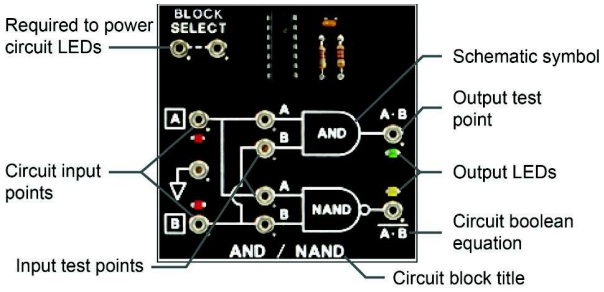
The inputs and outputs of seven circuit blocks have LEDs to indicate the logic state of the signal, as shown on the AND/NAND circuit block.



When the LED is on (glowing), the logic state is logic 1 (high).

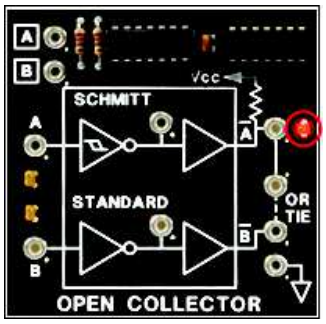


When the LED is off (not glowing), the logic state is logic 0 (low).

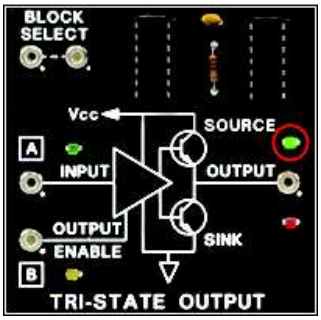


There are two exceptions to the LED on/off rule:

1. In the OPEN COLLECTOR circuit block, the LED is on when the output is low. There is no input LED in this circuit block.

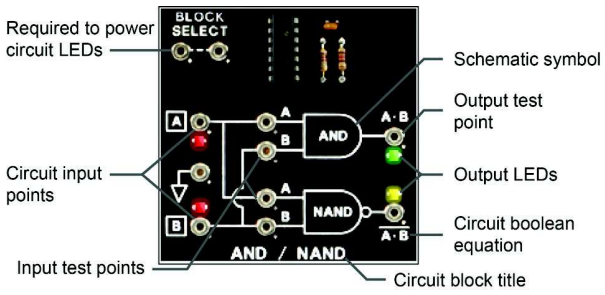


2. In the TRI-STATE OUTPUT circuit block, the SOURCE LED is on when the output is low.



The color of the LEDs differentiates the inputs from the outputs.

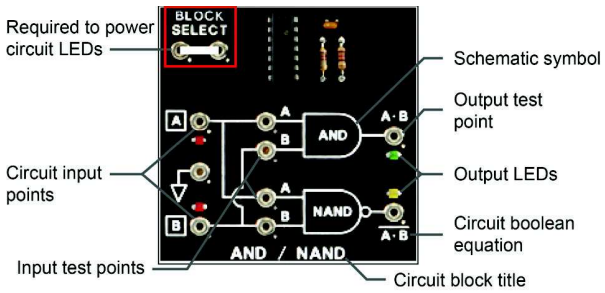
The logic state of the signal is not associated with the LED color.



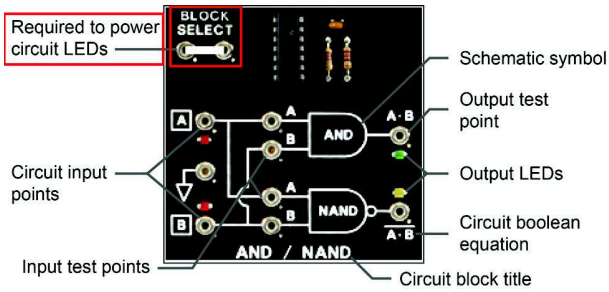
When the logic gate input or output LED is on (glowing) in the AND/NAND circuit block, the logic state is

a. logic 1 (high).
b. logic 0 (low).

On six of the circuit blocks with LEDs, there is a BLOCK SELECT label with two terminals for a two-post connector.

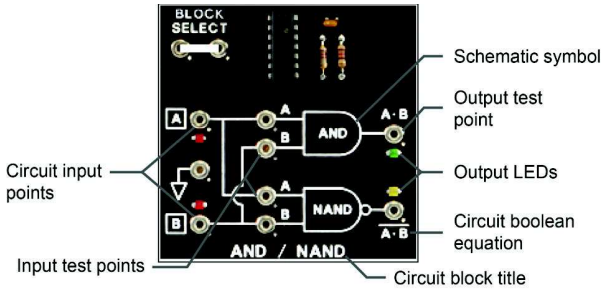


To activate the LEDs on these circuits, a two-post connector has to be inserted in the BLOCK SELECT terminals.

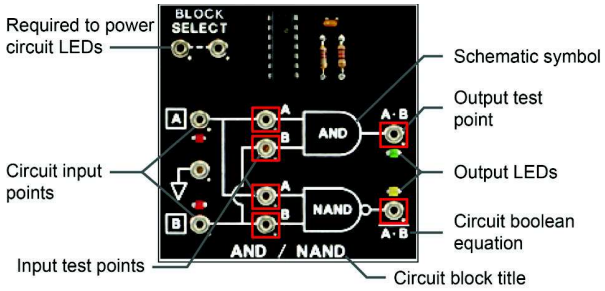


When a two-post connector is inserted in the BLOCK SELECT terminals, the circuit block LEDs are

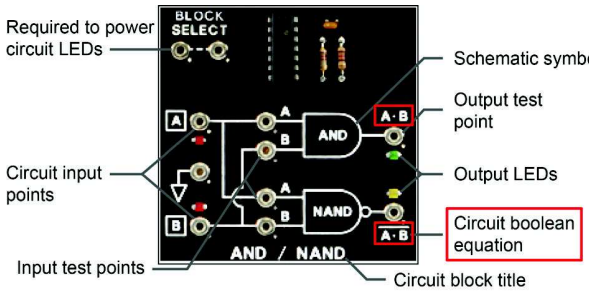
a. not activated to indicate logic states of the inputs and outputs.
b. activated to indicate logic states of the inputs and outputs.



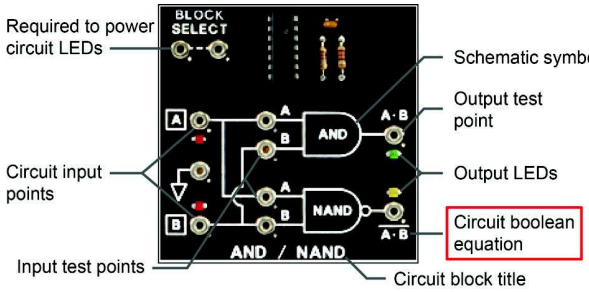
Test points are provided for input and output logic level verification with a voltmeter or an oscilloscope.



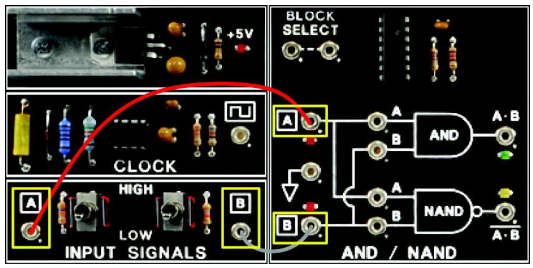
Silkscreen schematic symbols and Boolean equations indicate circuit functions.



You will determine logic levels of the inputs and outputs by observing the status of the LEDs or by measuring the voltage level with a voltmeter or an oscilloscope.

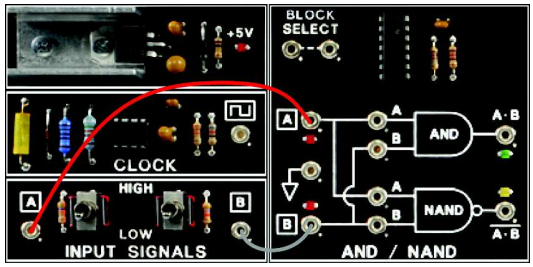


FACET test leads (interconnecting leads) are used to connect circuit inputs (A and B) to the outputs at the INPUT SIGNALS or CLOCK circuit blocks.



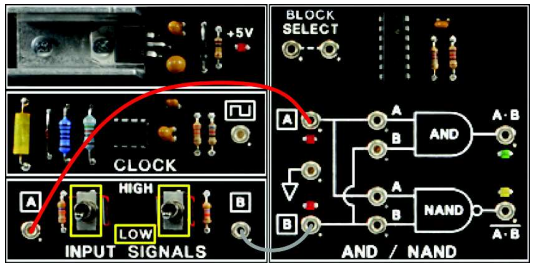
In the circuit shown here, a test lead connects output A of the INPUT SIGNALS circuit block to

a. input B of the AND/NAND circuit block.
b. input A of the AND/NAND circuit block.

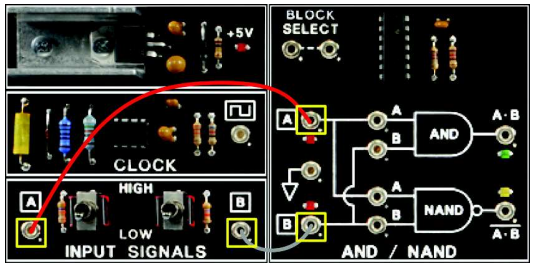


PROCEDURE

☐ 1. Locate the circuit blocks shown. Set toggle switches A and B on the INPUT SIGNALS circuit block to the LOW position.

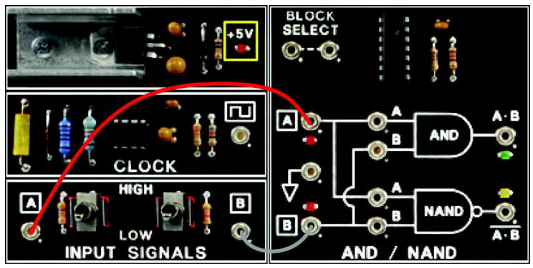


Using two test leads, connect A and B on the INPUT SIGNALS circuit block to A and B, respectively, on the AND/NAND circuit block.



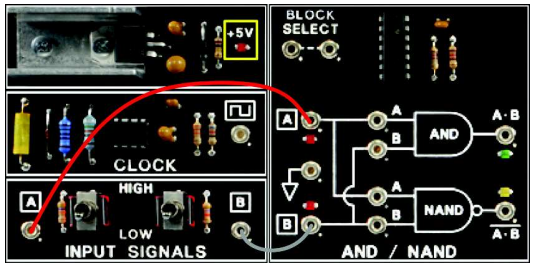
☐ 2. Is the +5 V on the POWER SUPPLY REGULATOR (not labeled) circuit block on (glowing)?

a. yes
b. no



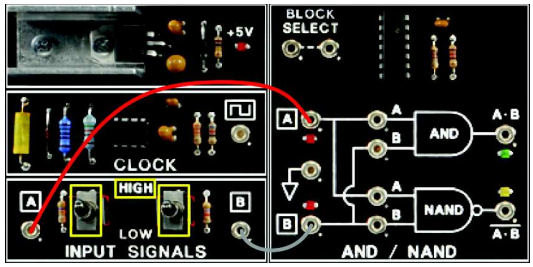
☐ 3. When the +5 V LED is on, is 5 Vdc power supplied to the gates and circuits on the circuit board?

a. yes
b. no



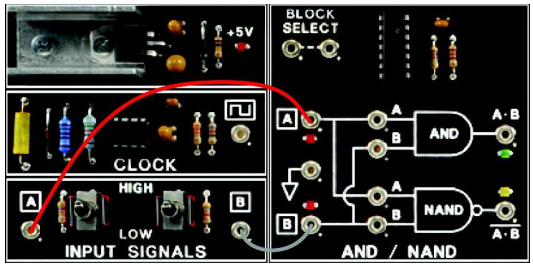
4. Set toggle switches A and B to the HIGH position. Did any of the LEDs on the AND/NAND circuit block turn on (glow)?

   a. yes
   b. no



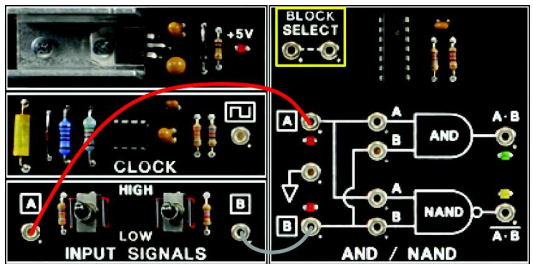
5. The LEDs are not on because

   a. 5 Vdc power is not being supplied to the circuit block.
   b. a two-post connector is not inserted in the BLOCK SELECT terminals.



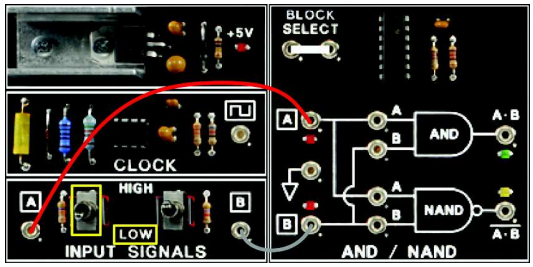
6. Insert a two-post connector in the BLOCK SELECT terminals on the AND/NAND circuit block. Did some of the LEDs turn on?

   a. yes
   b. no

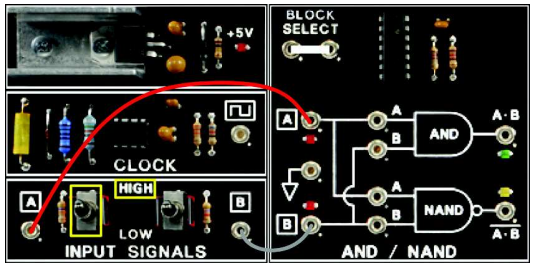


7. Set toggle switch A to the LOW position. Which LEDs went off?

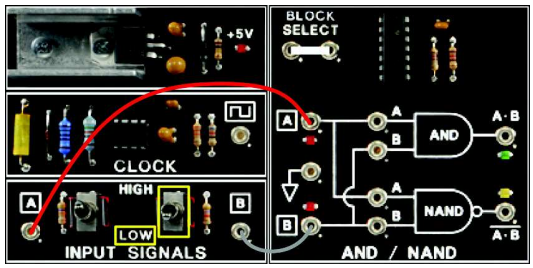
   a. The input B LED and the NAND gate output LED.
   b. The input A LED and the AND gate output LED.



Set toggle switch A to the HIGH position.



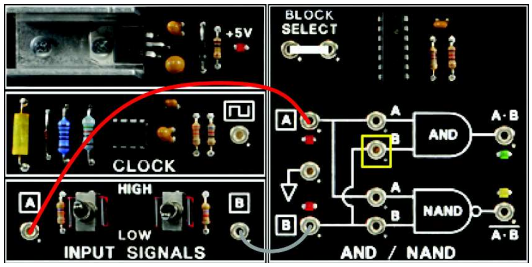
Set toggle switch B to the LOW position.

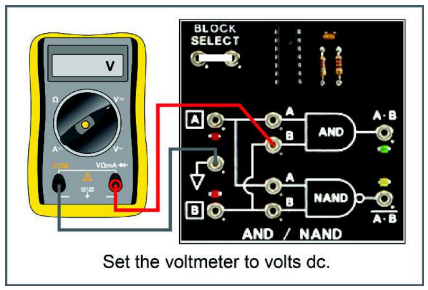


☐ 8. Which LEDs are off?

a. The input B LEDs and the AND gate output LED.
b. The input A LEDs and the NAND gate output LED.

☐ 9. Connect the red lead of a voltmeter to input B of the AND gate, and connect the black common lead to a ground terminal. Set the voltmeter to measure volts dc.





Set the voltmeter to volts dc.

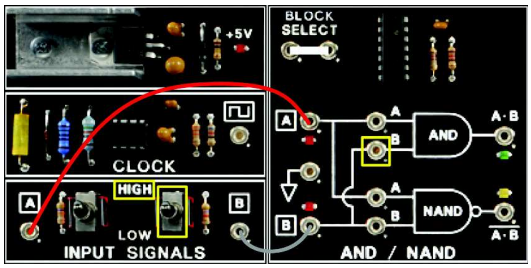
☐ 10. The voltmeter indicates that input B is

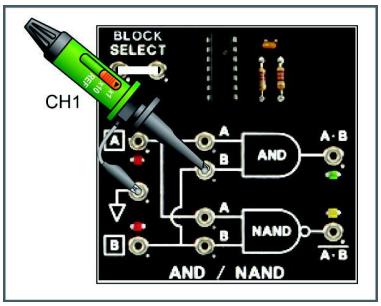
a. high (logic 1).
b. low (logic 0).

☐ 11. Set toggle switch B to the HIGH position. The voltmeter indicates that input B is

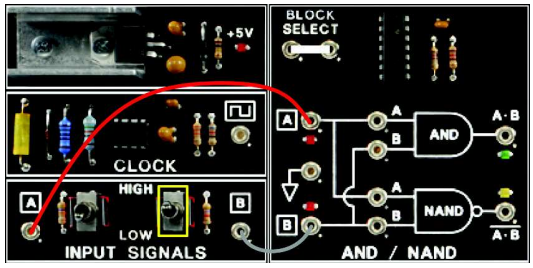
a. high (logic 1).
b. low (logic 0).

☐ 12. Connect the oscilloscope channel 1 probe to input B of the AND gate, and connect the probe ground clip to a ground terminal.



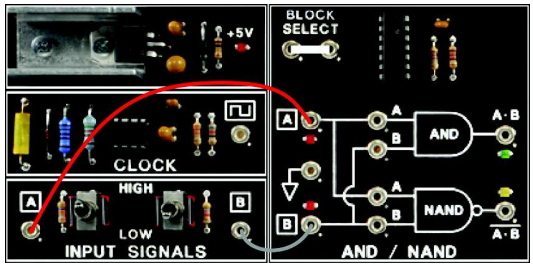


Set toggle switch B from HIGH to LOW and back to HIGH while observing the signal on channel 1 of the oscilloscope and the LED at input B.



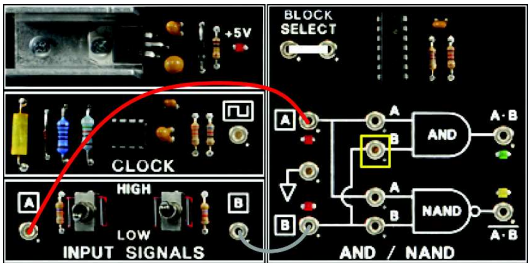
☐ 13. The input B signal went from

a. logic 1 to logic 0 to logic 1.
b. logic 0 to logic 1 to logic 0.

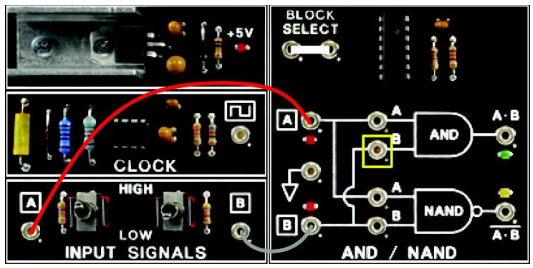


☐ 14. When the input B LED is on, the channel 1 signal indicates that the input B signal is

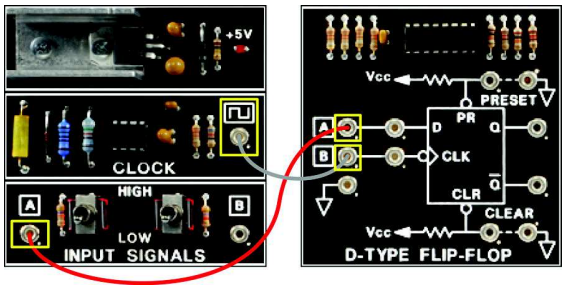
a. high.
b. low.

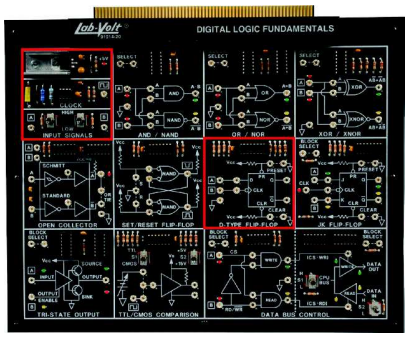


15. When the channel 1 signal indicated that input B was low, the input B LED was
    a. on.
    b. off.



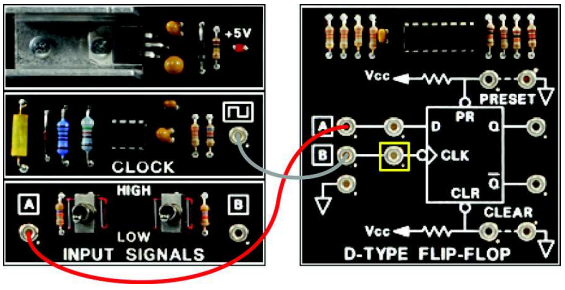
16. Locate the D-TYPE FLIP-FLOP circuit block, and connect the circuit shown here.

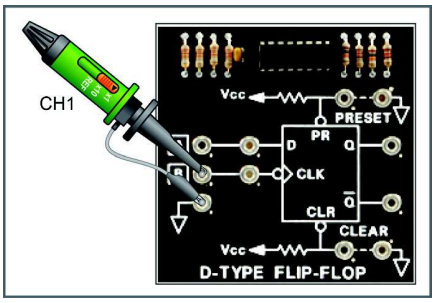




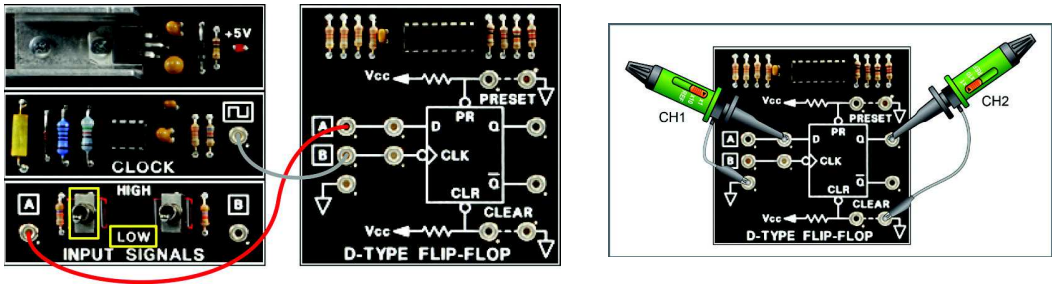
The A terminal of the INPUT SIGNALS circuit block connects to input A at the D-TYPE FLIP-FLOP circuit block. The output of the CLOCK circuit block connects to input B of the D-TYPE FLIP-FLOP circuit block. (Notice that the D-TYPE FLIP-FLOP does not have input and output LEDs.)

17. Connect the oscilloscope channel 1 probe to the CLK input at the D-TYPE FLIP-FLOP circuit block, and connect the probe ground clip to a ground terminal on the circuit board. The signal you observe on channel 1 is a
    a. logic 1 signal.
    b. logic 0 signal.
    c. 50 kHz square wave.

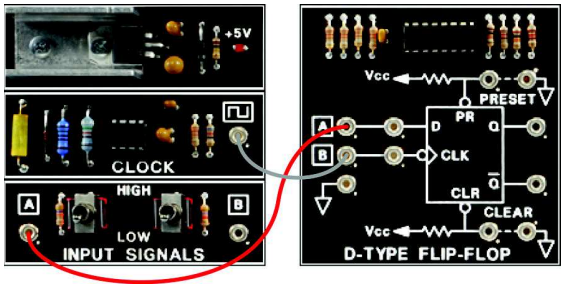




☐ 18. Set toggle switch A on the INPUT SIGNALS circuit block to LOW.



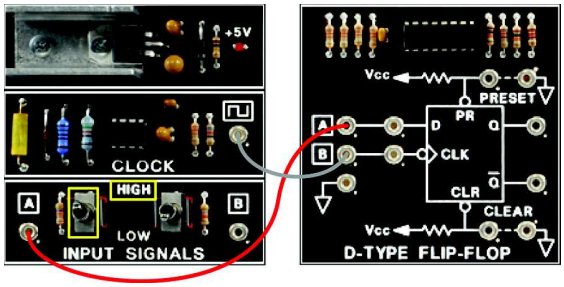
Connect the oscilloscope channel 1 probe to input D at the D-TYPE FLIP-FLOP circuit block. Connect the oscilloscope channel 2 probe to output at the D-TYPE FLIP-FLOP circuit block, and connect the probe ground clip to a ground terminal.



☐ 19. While observing the oscilloscope channel 1 and 2 signals, set toggle switch A from LOW to HIGH to LOW to HIGH. The channel 1 and 2 signals changed from

a. logic 1 to logic 0 to logic 1 to logic 0.
b. logic 0 to logic 1 to logic 0 to logic 1.

☐ 20. Toggle switch A should be set to HIGH.



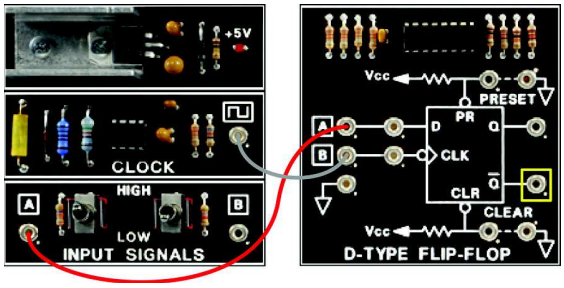
Connect the channel 2 probe to output $\overline{Q}$ of the D-TYPE FLIP-FLOP circuit block. Does the output $\overline{Q}$ signal on channel 2 have the same logic state (HIGH) as the input A signal on channel 1?

a. yes
b. no

21. Set toggle switch A from HIGH to LOW to HIGH.

Does the output signal on channel 2 always have the complementary (opposite) logic state to the input signal on channel 1?

a. yes
b. no



CONCLUSION

- Test leads connect the terminals at the CLOCK and INPUT SIGNALS circuit blocks to the input terminals at the logic gate circuit blocks.
- A two-post connector has to be installed in the BLOCK SELECT terminals for the input and output LEDs to function.
- When an LED is on (glowing), the logic state is normally high (logic 1).
- When an LED is off (not glowing), the logic state is normally low (logic 0).
- The logic states of circuit inputs and outputs can also be observed with a voltmeter or with an oscilloscope.

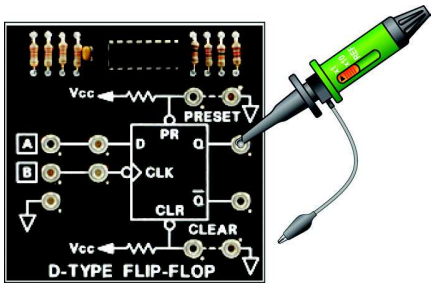
REVIEW QUESTIONS

1. The output of the CLOCK circuit block is connected to the CLK input of the D-TYPE FLIP-FLOP circuit block with a
   a. printed circuit copper path.
   b. two-post connector.
   c. test lead.
   d. All of the above.

2. A circuit is connected properly, and the +5 V LED is on; however, the circuit input and output LEDs are not functioning. The LEDs are not functioning because
   a. the INPUT SIGNALS circuit block A and B toggle switches are not set to the HIGH position.
   b. the CLOCK signal is not functioning.
   c. a two-post connector is not installed in the BLOCK SELECT terminals.
   d. the 15 Vdc power supply is not turned on.

3. The LED for input B to the AND/NAND circuit block is on. The logic state of input B is
   a. low.
   b. high.
   c. high-Z.
   d. indeterminate.

4. What is wrong with the oscilloscope connection to output Q of the D-type flip-flop? The probe ground clip is not connected to
   a. output $\overline{Q}$.
   b. the CLR terminal.
   c. the PR terminal.
   d. a ground terminal.



5. The logic states of the circuit inputs and outputs on the DIGITAL LOGIC FUNDAMENTALS circuit board can be determined
   a. by the status of the LEDs.
   b. with a voltmeter.
   c. with an oscilloscope.
   d. All of the above.